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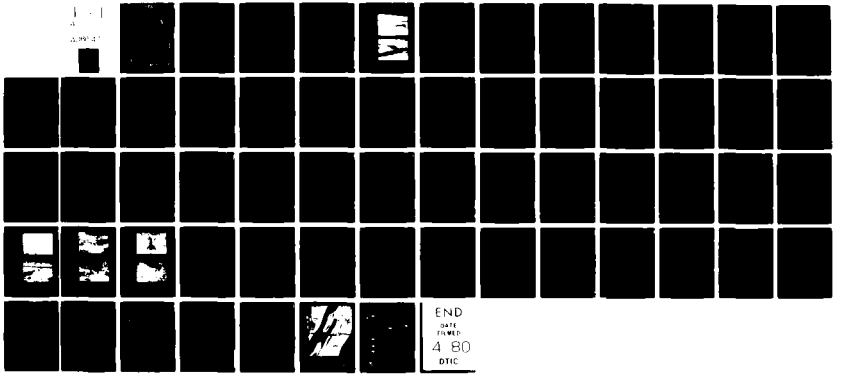

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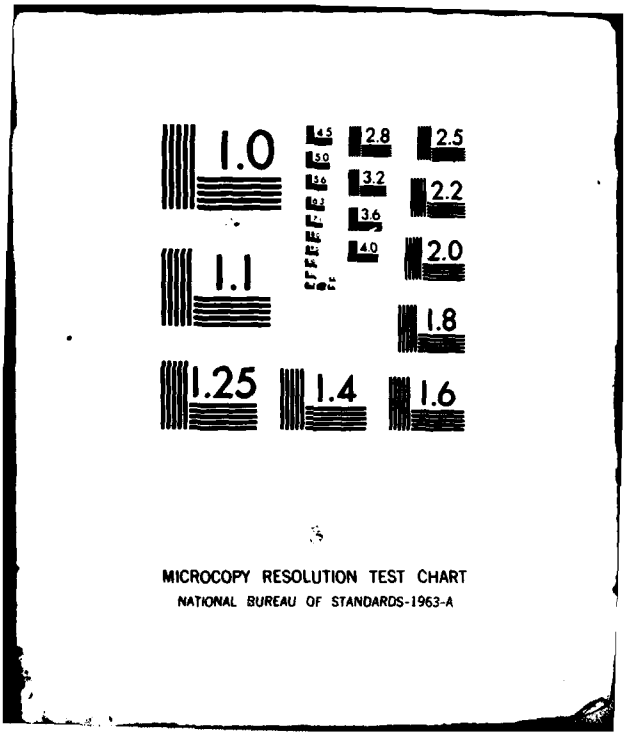
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LEVEL II

SUSQUEHANNA RIVER BASIN
UNNAMED TRIBUTARY OF RAYSTOWN BRANCH JUNIATA RIVER
BEDFORD COUNTY

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(6) National Dam Inspection Program.
TODD SPRING RESERVOIR
(NDI ID [redacted] PA-00241,
DER ID [redacted]5-6), Number Number
Susquehanna River Basin,
Unnamed Tributary of Raystown Branch
Juniata River, Bedford County, Pennsylvania.
PHASE I INSPECTION REPORT,
NATIONAL DAM INSPECTION PROGRAM

(15) DACW31-80-C-0022
↓
per
Betty Perkins
Corps of Engineers,
Baltimore, Md

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PREPARED FOR (10) Lawrence D. Andersen
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND 21203

(11) 1980

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BY

D'APPOLONIA CONSULTING ENGINEERS
10 DUFF ROAD
PITTSBURGH, PA. 15235

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JOB

(6)

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Department of the Army, Office of Chief of Engineers, Washington, D.C. 20314.

The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon visual observations and review of available data. Detailed investigations and analyses involving topographic mapping, subsurface investigations, material testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the inspection is intended to identify any need for such studies which should be performed by the owner.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external factors which are evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The assessment of the conditions and recommendations was made by the consulting engineer in accordance with generally and currently accepted engineering principles and practices.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM: Todd Spring Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Bedford
STREAM: Unnamed tributary of the Raystown Branch of the Juniata River
SIZE CLASSIFICATION: Small
HAZARD CLASSIFICATION: High
OWNER: Borough of Bedford
DATE OF INSPECTION: November 19 and December 12, 1979

ASSESSMENT: Based on the evaluation of the existing conditions, the condition of the Todd Spring Dam embankment is considered to be good. However, due to the seriously inadequate spillway capacity, the dam is classified to be unsafe/nonemergency.

Field observations indicate that the dam crest and the center of the embankment have settled relative to the abutments. The crest elevations range between 1.5 feet above the spillway crest level at the center of the embankment and 3.8 feet above the spillway crest level near the right abutment. The remaining portions of the embankment and the spillway structures were found to be in good condition, revealing no signs of distress.

The flow through the outlet pipe is controlled by a valve located downstream of the dam which causes the pipe to be under pressure through the embankment. Because no information is available on the manner in which the pipe through the embankment was constructed, concern exists as to the effect of a rupture of this pipe on the embankment stability. Therefore, the owner should develop a means for upstream control.

The flood discharge capacity of the dam was evaluated according to the recommended procedure and was found to pass less than 20 percent of the probable maximum flood (PMF). Therefore, according to the recommended criteria, the flood discharge capacity of the dam is classified to be inadequate. Because the capacity of the spillway is less than 50 percent PMF and because the overtopping of the embankment is likely to lead to a breach failure, significantly increasing the downstream damage potential, the spillway is classified to be seriously inadequate. However, it was noted that filling of the low areas on the crest of the dam would increase spillway capacity to about 50 percent PMF.

The following recommendations should be implemented immediately or on a continuing basis:

1. The owner should immediately retain a professional engineer to initiate additional studies to more accurately ascertain the spillway capacity and the nature and extent of improvements required to provide adequate spillway capacity. Filling of the low areas on the crest of the dam should be considered in conjunction with this investigation.

2. The structural integrity of the outlet pipe through the embankment should be investigated and a means for providing upstream control on the outlet pipe should be developed.

3. The operational condition of the outlet works sluice gate should be evaluated and necessary maintenance performed.

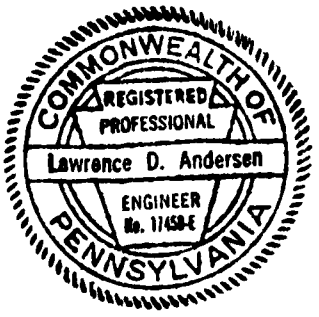
4. The upstream face of the dam should be provided with adequate erosion protection to avoid shoreline erosion.

5. Around-the-clock surveillance should be provided during unusually heavy runoff and a formal warning system developed to alert the downstream residents in the event of emergencies.

6. The dam and appurtenant structures should be inspected regularly and necessary maintenance performed.

Lawrence D. Andersen, P.E.
Vice President

January 28, 1980
Date

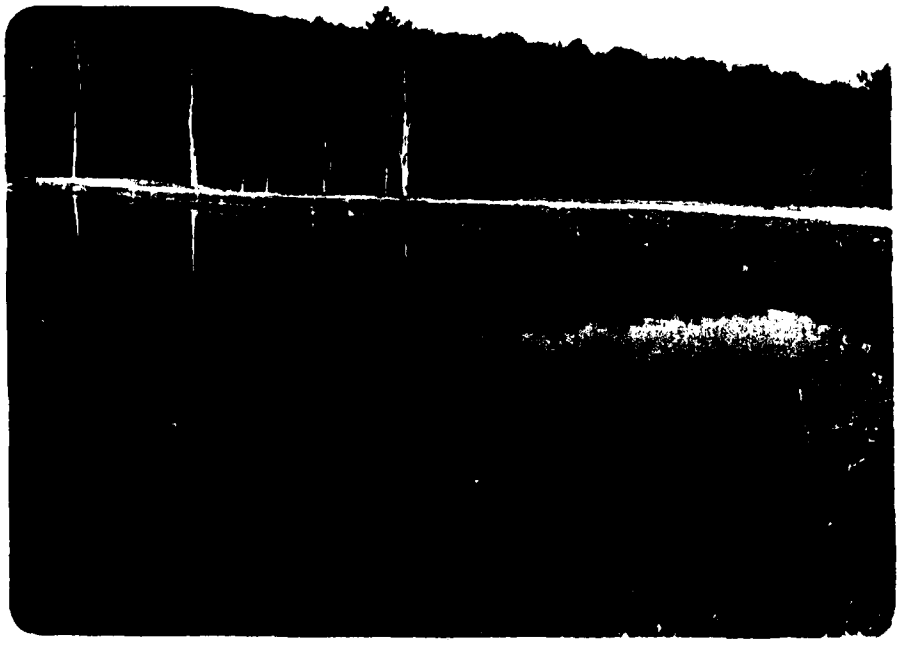


Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

25 Feb 1980
Date

TODD SPRING DAM
NDI I.D. PA-241
NOVEMBER 19, 1979



Upstream Face

Downstream Face

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
TODD SPRING DAM
NDI I.D. PA-241
DER I.D. 5-6

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Dam and Appurtenances. Todd Spring Dam consists of an earth embankment approximately 625 feet long with a maximum height of 32 feet from the downstream toe. The crest width is variable and ranges from 50 feet near the left abutment to about 30 feet at the center of the embankment. The downstream face of the dam is covered with well established grass and is on a slope of approximately 1-1/2 horizontal to 1 vertical. Flood discharge facilities for the reservoir consist of a concrete overflow structure located near the right abutment (looking downstream). The spillway overflow structure discharges into a stone paved channel which terminates approximately 75 feet downstream from the control point. This channel, in turn, discharges into an earth channel. As far as could be determined from visual observations, the outlet works consist of a 18-inch cast-iron pipe through the embankment with flow controlled by valves in the valve chamber near the downstream toe of the dam. An 18-inch blow-off valve on the outlet pipe constitutes the emergency drawdown facility for the reservoir.

b. Location. Todd Spring Dam is located approximately one mile west of Bedford in Bedford Township, Bedford County, Pennsylvania. The dam is located across an unnamed tributary of the Raystown branch of the Juniata River approximately one mile upstream from its confluence with the Juniata River (Plate 1).

c. Size Classification. Small (based on 32-foot height and 85 acre-feet storage capacity).

d. Hazard Classification. The dam is classified to be in the high hazard category. The Bedford County fairgrounds and urban residential areas are located approximately 1/2 mile downstream from the dam. It is therefore estimated that failure of the dam would cause large loss of life and property damage in these areas.

e. Ownership. Bedford Borough (address: Mr. James Montgomery, Borough Manager, Bedford Borough, 244 West Penn Street, Bedford, Pennsylvania 15522).

f. Purpose of Dam. Water Supply.

g. Design and Construction History. According to a state report dated June 27, 1916, the dam was constructed in about 1898 by Mr. John W. Ruthford, a general contractor from New York City.

h. Normal Operating Procedure. The reservoir is normally maintained at the crest level of the uncontrolled spillway. The inflow occuring when the lake is at or above the spillway crest level is discharged through the uncontrolled spillway.

1.3 Pertinent Data

a. Drainage Area	0.6 square miles
b. Discharge at Dam Site (cfs)	
Maximum known flood at dam site	Unknown
Outlet conduit at maximum pool	Unknown
Gated spillway capacity at maximum pool	Not applicable
Ungated spillway capacity at maximum pool	220(1)
Total spillway capacity at maximum pool	220
c. Elevation (USGS Datum) (feet)	
Top of dam	1225.5 (measured low spot)
Maximum pool	1225.5
Normal pool	1224
Upstream invert outlet works	Unknown
Downstream invert outlet works	Unknown
Streambed at center line of dam	1190±
Maximum tailwater	Unknown
Toe of dam	1193±

(1) See Appendix D, Page D4 of 4, line outflow.

d. Reservoir Length (feet)

Normal pool level	500
Maximum pool level	550+

e. Storage (acre-feet)

Normal pool level	76
Maximum pool level	85

f. Reservoir Surface (acres)

Normal pool level	3.7
Maximum pool level	4+

g. Dam

Type	Earth
Length	625 feet
Height	32 feet
Top width	30 to 50 feet
Side slopes	Downstream: 1-1/2H:1V; Upstream: 2H:1V(1)
Zoning	Unknown
Impervious core	Unknown
Cutoff	Unknown
Grout curtain	Post-Construction Grouting in 1920 and 1961

h. Regulating Outlet

Type	18-inch cast-iron pipe
Length	Unknown
Closure	Gate valve at downstream end
Access	Valve chamber
Regulating facilities	Gate valve

i. Spillway

Type	Concrete overflow section

(1) Estimated.

Length	54 feet (perpendicular to flow)
Crest elevation	1224
Upstream channel	Lake
Downstream channel	Stone paved trapezoidal channel

SECTION 2
DESIGN DATA

2.1 Design

a. Data Available. The available data consist of files provided by the Commonwealth of Pennsylvania, Department of Environmental Resources (PennDER) which contain correspondence and inspection reports and several plans obtained from the owner's records.

(1) Hydrology and Hydraulics. No design information is available.

(2) Embankment. No information is available on the original design and construction of the dam. Available information consists of past inspection reports and correspondence describing the post-construction work undertaken in 1920 and 1961.

(3) Appurtenant Structures. No information is available on the design of the appurtenant structures.

b. Design Features

(1) Embankment. A 1916 state report indicates that the dam (Plate 2) was built in about 1898. The same report indicates that there was no design and construction information available for the dam. In this report, extensive seepage was reported along the entire downstream toe of the dam, attributed to lack of an effective cutoff wall or to the failure in obtaining a proper bond between the subsurface soil and the base of the embankment during construction. Subsequent correspondence indicates that in 1920 a grouting program was undertaken to control seepage through the dam and its foundation. This grouting program appears to have consisted of drilling, pressure testing, and grouting six holes drilled through the crest of the dam into its foundation. Upon the completion of this 1920 grouting program, additional grouting consisting of approximately 100 holes was recommended. However, the available records do not indicate whether this additional grouting program was undertaken. Available information indicates that in 1961 a second grouting program was undertaken to control the seepage through the embankment. In this grouting program, which was conducted under the supervision of Pride Engineering Associates of Pittsburgh, Pennsylvania, a total of 290 holes were drilled and grouted. Subsequent inspection reports indicate that this grouting program was successful in stopping the leakage through the embankment.

(2) Appurtenant Structures. The appurtenant structures consist of a combined emergency and primary spillway located on the right

abutment and outlet works. The spillway is comprised of a concrete overflow section, a stone paved discharge channel which terminates approximately 75 feet downstream from the overflow structure. A 54-foot-wide concrete overflow section is 1.5 feet below the low spot on the crest and constitutes a sharp crested hydraulic control section.

The outlet works for the dam consist of an 18-inch cast-iron combined supply and blow-off line and the valve chamber at the toe level of the dam. No design information is available on the details of the construction of the outlet pipe through the embankment. Flow through the outlet pipe is controlled by the valves in the valve chamber.

c. Design Data

(1) Hydrology and Hydraulics. No design data are available.

(2) Embankment. No engineering data are available on the design of the embankment.

(3) Appurtenant Structures. No design information is available on the appurtenant structures.

2.2 Construction. According to a 1916 state report, the dam was constructed in about 1898 by Mr. John W. Ruthford, a general contractor from New York City. No other information is available on the construction of the dam.

Other than the two grouting programs undertaken in 1920 and 1961, respectively, available information indicates no other major post-construction changes.

2.3 Operation. It is reported that there are no formal operating records maintained for the dam.

2.4 Other Investigations. None.

2.5 Evaluation

a. Availability. The available information was provided by PennDER and the Borough of Bedford.

b. Adequacy

(1) Hydrology and Hydraulics. No information is available.

(2) Embankment. No design and construction information is available to assess the adequacy of the design of the embankment.

(3) Appurtenant Structures. No design information is available for the appurtenant structures.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of Todd Spring Dam consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.

2. Visual examination of the spillway and the visible portions of the outlet works.

3. Evaluation of downstream area hazard potential.

The specific observations are illustrated in Plate 3.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural distress, such as cracks, subsidence, bulging, wet areas, seeps and boils, and observing general maintenance conditions, vegetative cover, erosion, and other surficial features.

In general, the condition of the dam is considered to be good. Other than a minor seep inside the valve house at the downstream toe of the dam, which was estimated to be on the order of 2 to 4 gallons per minute (gpm), no seepage was found along the downstream toe of the dam. An irregularity was observed on the downstream slope near the left abutment. This irregularity is assumed to be an as-built feature of the embankment since no indication was found to suggest that it is associated with any movement on the downstream face of the dam.

The crest of the dam was surveyed relative to the spillway crest elevation and it was found that the middle one-third of the embankment is approximately 1.5 feet below the crest level near the abutment. The dam crest profile is illustrated in Plate 4.

c. Appurtenant Structures. The spillway structures were examined for deterioration or other signs of distress that would limit flow. In general, the spillway structures, which consist of a concrete overflow section and a stone paved discharge channel were found to be in fair condition. A section of the spillway channel approximately 200 feet downstream from the overflow section is blocked by trash and debris. However, it appears that this blockage would not affect the discharge capacity of the spillway.

The only visible portion of the outlet works is the portion of the of the outlet pipe within the valve house. The blow-off pipe appears to be an 18-inch pipe leading from the outlet pipe through the embankment. However, the downstream end of the blow-off pipe could not be located.

d. Reservoir Area. A map review indicates that the watershed is predominantly covered by woodlands. A review of the regional geology (Appendix F) indicates that the shorelines of the reservoir are likely to be susceptible to landslides. However, massive landslides which would affect the storage volume of the reservoir or cause overtopping of the dam by displaced water are not considered to be likely.

e. Downstream Channel. Below the dam, the stream flows adjacent to Bedford County fairgrounds, then under Route 30, through residential areas of Bedford, and joins the Raystown branch of the Juniata River approximately one mile downstream from the dam. A further description of the downstream conditions is included in Section 1.2(d).

3.2 Evaluation. The maintenance condition of the embankment is considered to be good. The operational condition of the blow-off valve could not be observed. Therefore, it is recommended that the blow-off valve should be operated and necessary maintenance performed. A means for providing upstream flow control on the outlet pipe should be developed.

SECTION 4
OPERATIONAL FEATURES

4.1 Procedure. There are no formal operating procedures for the dam. The reservoir is normally maintained at the uncontrolled primary spillway crest level with excess inflow discharging over the spillway.

4.2 Maintenance of the Dam. The maintenance of the dam is considered to be good. The downstream face of the dam is covered with grass and appears to be periodically mowed. The trash in the spillway discharge channel, although it would not appear to affect the hydraulic performance of the spillway, should be cleared from the channel as a maintenance effort.

4.3 Maintenance of Operating Facilities. The maintenance condition of the operating facilities is considered to be poor. The maintenance personnel reported that the blow-off valve has not been operated in the recent past and the operational condition of the valve is questionable. The operation of the blow-off valve was not observed. Further, the downstream end of the blow-off pipe could not be located. It appears that the downstream end of the pipe could have been buried beneath the fill which has been placed downstream from the dam.

4.4 Warning System. No formal warning system exists for the dam. Telephone communication facilities are available approximately 1/2 mile downstream from the dam.

4.5 Evaluation. While the maintenance condition of the dam is considered to be good, the maintenance of the operating facilities was found to be poor. It is recommended that the operational condition of the blow-off valve should be evaluated and necessary maintenance performed.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. Todd Spring Dam has a watershed of 0.64 square mile and impounds a reservoir with a surface area of 3.7 acres at normal pool level. The flood discharge facilities for the dam consist of a combined primary and emergency spillway located near the right abutment. The capacity of the spillway was determined to be 220 cfs based on the available 1.5-foot freeboard relative to the low spot on the crest of the embankment.

b. Experience Data. As previously stated, Todd Spring Dam is classified as a small dam in the high hazard category. Under the recommended criteria for evaluating emergency spillway discharge capacity, such impoundments are required to pass half to full PMF.

The PMF inflow hydrograph for the reservoir was determined utilizing the Dam Safety Version of the HEC-1 computer program developed by the Hydrologic Engineering Center of the U.S. Army, Corps of Engineers. Data used for the computer analysis are presented in Appendix D. The PMF inflow hydrograph was found to have a peak flow of 1610 and 805 cfs for full and 50 percent of PMF, respectively. Computer input and summary of computer output are also included in Appendix D.

c. Visual Observations. On the date of inspection, no conditions were observed that would indicate that the capacity of the spillway would be signficantly reduced in the event of a flood.

d. Overtopping Potential. Various percentages of PMF inflow hydrograph were routed through the reservoir, and it was found that the spillway crest can pass less than 20 percent of the PMF without overtopping at the low spot on the crest of the dam. For 50 percent of the PMF, the low spot on the crest would be overtopped for a duration of 7.3 hours with a maximum depth of 0.69 foot. For 100 percent of the PMF, the overtopping duration would be 10.3 hours with a maximum depth of overtopping of 1.14 feet over the low spot on the crest. It is estimated that the filling of the low area on the crest to the abutment crest levels, which is approximately 1.5 feet above the spillway crest level, will increase the spillway capacity to approximately 50 percent of the PMF.

e. Spillway Adequacy. Since the spillway cannot pass the recommended design flood of half to full PMF without overtopping the embankment, the spillway is classified to be inadequate according to the recommended criteria. Further, since the spillway capacity is less than 50 percent of the PMF and overtopping of the embankment is considered to present significant breach potential which would increase flood damage downstream significantly compared to the discharge (approximately 220 cfs) that would exist just before overtopping failure, the spillway is considered to be seriously inadequate.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

(1) Embankment. As discussed in Section 3, the field observations did not reveal any signs of distress that would significantly affect the stability of the dam at this time, and none were reported in the past after the completion of the grouting program in 1961. Significant seepage reported prior to the 1961 grouting program appears to have been effectively controlled by the grouting conducted in 1961.

(2) Appurtenant Structures. The structural performance of the spillway facilities appears to be satisfactory. Because only a very small portion of the blow-off pipe was visible and the downstream end of the blow-off could not be located, no conclusions were reached as to the structural adequacy of the blow-off pipe. Because the downstream controls on the outlet pipe which cause the pipe to be under pressure through the embankment and no design information is available, it is considered advisable that the structural adequacy of the outlet pipe should be evaluated and a means for placing upstream control on the pipe should be developed.

b. Design and Construction Data

(1) Embankment. The dam was constructed in 1898 when limited understanding of geotechnical behavior of earth structures existed. Although no design and construction information is available, these data are not likely to have included any quantitative information to aid in the assessment of stability. As previously noted, the dam has adequately performed following the grouting program conducted in 1961 and no signs of distress were noted at this time. Therefore, the static stability of the dam is considered to be adequate.

(2) Appurtenant Structures. No design and construction data are available for the appurtenant structures.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. Two foundation grouting programs undertaken in 1920 and 1961, respectively, were discussed in Section 2.1(b).

e. Seismic Stability. The dam is located in Seismic Zone 1 and based on visual observations, the static stability of the dam is considered to be adequate. Therefore, based on the recommended criteria for the evaluation of seismic stability of dams, the structure is presumed to present no hazard from earthquakes.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. The visual observations indicate that the Todd Spring Dam embankment is in good condition. No conditions were observed that would significantly affect the overall performance of the structure and none have been reported after the completion of the 1961 grouting program. However, in view of the seriously inadequate spillway capacity, the dam is classified to be unsafe/non-emergency.

It is reported that the operational condition of the blow-off valve is questionable. It is therefore recommended that the operational condition of the blow-off valve be evaluated and necessary maintenance performed. As discussed in Section 6.1(a), the need for placing an upstream control on the outlet pipe should also be evaluated.

Spillway capacity was evaluated according to the recommended procedure and was found to be less than 20 percent of the PMF without overtopping the embankment. This capacity is less than the recommended spillway capacity of the half to full PMF according to the size and hazard classification for this dam. Further, because the spillway capacity is less than 50 percent of the PMF and it is estimated that overtopping of the embankment could lead to a breach failure which would significantly increase the downstream damage potential, the spillway is classified to be seriously inadequate.

b. Adequacy of Information. The available information, in conjunction with the visual observations and the previous experience of the inspectors, is considered to be sufficient to make the following recommendations.

c. Urgency. The following recommendations should be implemented immediately or on a continuing basis.

d. Necessity for Additional Data. In view of the seriously inadequate spillway capacity, the owner should immediately initiate additional studies to more accurately ascertain the spillway capacity and the extent of improvements required to provide adequate spillway capacity.

7.2 Recommendations/Remedial Measures. It is recommended that:

1. The owner should immediately retain a professional engineer to initiate additional studies to more accurately ascertain the

spillway capacity and the nature and extent of improvements required to provide adequate spillway capacity. Filling of the low areas on the crest of the dam should be considered in conjunction with this investigation.

2. The structural integrity of the outlet pipe through the embankment should be investigated and a means for providing upstream control on the outlet pipe should be developed.

3. The operational condition of the outlet works sluice gate should be evaluated and necessary maintenance performed.

4. The upstream face of the dam should be provided with adequate erosion protection to avoid shoreline erosion.

5. Around-the-clock surveillance should be provided during unusually heavy runoff and a formal warning system developed to alert the downstream residents in the event of emergencies.

6. The dam and appurtenant structures should be inspected regularly and necessary maintenance performed.

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

NDI I.D. PA-241

NAME OF DAM Todd Spring Dam COUNTY Bedford STATE Pennsylvania ID# DER I.D. 5-6

TYPE OF DAM Earth HAZARD CATEGORY High

DATE(S) INSPECTION November 19, 1979 WEATHER Cloudy TEMPERATURE 50s

POOL ELEVATION AT TIME OF INSPECTION 1224.1 M.S.L. TAILWATER AT TIME OF INSPECTION 1190± M.S.L.

INSPECTION PERSONNEL:	REVIEW INSPECTION PERSONNEL: (December 12, 1979)
B. Erel	L. D. Andersen
W. T. Chan	J. H. Poellot
	B. Erel

B. Erel RECORDER

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Minor erosion rills on the downstream slope near the right abutment.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Middle one third of the embankment was found to be approximately 1.5 feet lower than the abutments. See Plate 4 for the dam crest profile.	
RIPRAP FAILURES	There is no erosion protection on the upstream side of the dam.	The owner should evaluate the need for providing erosion protection.

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No signs of distress.	
ANY NOTICEABLE SEEPAGE	One wet area on the left side of the valve house along the toe of the dam. Seepage on the order of 2 to 4 gallons per minute within the valve house.	
STAFF GAGE AND RECORDER	None	
DRAINS	None	

VISUAL INSPECTION
PHASE I
OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet pipe is an 18-inch cast-iron pipe. The downstream end could not be located.	The owner should locate the downstream end of the blow-off pipe.
INTAKE STRUCTURE	Submerged	
OUTLET STRUCTURE	None	
OUTLET CHANNEL	None	
EMERGENCY GATE	The maintenance personnel reported that the blow-off valve has not been operated in the recent past. Operation of the valve was not observed.	Operational condition of the blow-off valve should be evaluated and necessary maintenance performed.

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	In good condition.	
APPROACH CHANNEL	Submerged. Appears to be free of debris.	
DISCHARGE CHANNEL	First 75-foot section is a stone paved trapezoidal channel in good condition. A portion of the discharge channel 200 feet from the control section is blocked by trash.	The trash in the spillway discharge channel should be cleared.
BRIDGE AND PIERS	None	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable	
APPROACH CHANNEL	Not applicable	
DISCHARGE CHANNEL	Not applicable	
BRIDGE PIERS	Not applicable	
GATES AND OPERATION EQUIPMENT	Not applicable	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

VISUAL INSPECTION
PHASE I
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle to moderately steep. No significant shoreline erosion was noted.	
SEDIMENTATION	Unknown	
UPSTREAM RESERVOIRS	None	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No apparent obstructions immediately downstream of the dam that would affect the discharge capacity of the spillway.	
SLOPES	No features pertinent to the safety of the dam.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Bedford County fairgrounds, Route 30, and urban residential areas are located approximately 1/2 mile downstream from the dam. Population: Approximately 100.	

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
AND HYDROLOGIC AND HYDRAULIC
PHASE I

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Todd Spring Dam
ID# NDI I.D. PA-241
DER I.D. 5-6

ITEM	REMARKS
AS-BUILT DRAWINGS	None available
REGIONAL VICINITY MAP	See Plate 1
CONSTRUCTION HISTORY	The dam was constructed in 1898.
TYPICAL SECTIONS OF DAM	Not available
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	None available

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	Not available
DESIGN REPORTS	Not available
GEOLOGY REPORTS	Not available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Not available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Not available

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	None reported
BORROW SOURCES	Unknown
MONITORING SYSTEMS	None
MODIFICATIONS	Embankment foundation was grouted in 1921 and 1961.
HIGH POOL RECORDS	Not recorded

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Pressure Grouting Todd Reservoir, 1920, by Shirley C. Hulse, member of American Society of Civil Engineers, dated October 23, 1920. This report describes the grouting program conducted in 1920.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported
MAINTENANCE OPERATION RECORDS	Not recorded
SPILLWAY PLAN SECTIONS DETAILS	Not available
OPERATING EQUIPMENT PLANS AND DETAILS	Not available

CHECKLIST
ENGINEERING DATA
HYDROLOGIC AND HYDRAULIC

DRAINAGE AREA CHARACTERISTICS: 0.64 square mile (woodlands)

ELEVATION; TOP NORMAL POOL AND STORAGE CAPACITY: 1224 (76 acre-feet)

ELEVATION; TOP FLOOD CONTROL POOL AND STORAGE CAPACITY: 1225.5 (85 acre-feet)

ELEVATION; MAXIMUM DESIGN POOL: 1225.5

ELEVATION; TOP DAM: 1225.5 (measured low spot)

SPILLWAY:

a. Elevation 1224

b. Type Concrete overflow section

c. Width 36 feet (low flow section), 54 feet total width

d. Length Not applicable

e. Location Spillover Middle of embankment

f. Number and Type of Gates None

OUTLET WORKS:

a. Type 18-inch cast-iron pipe

b. Location Center of embankment

c. Entrance Inverts Unknown

d. Exit Inverts Unknown

e. Emergency Drawdown Facilities Blow-off pipe

HYDROMETEOROLOGICAL GAGES:

a. Type None

b. Location None

c. Records None

MAXIMUM NONDAMAGING DISCHARGE: 220 cfs (spillway capacity)

APPENDIX C

PHOTOGRAPHS

LIST OF PHOTOGRAPHS
TODD SPRING DAM
NDI I.D. PA-241
NOVEMBER 19, 1979

PHOTOGRAPH NO.	DESCRIPTION
1	Dam crest.
2	Spillway crest.
3	Spillway discharge channel, looking upstream.
4	Debris in spillway channel.
5	Outlet valve in valve house.
6	Route 30, 1/2 mile downstream, (flow from left to right).

Photograph No. 1

Dam crest.

Photograph No. 2

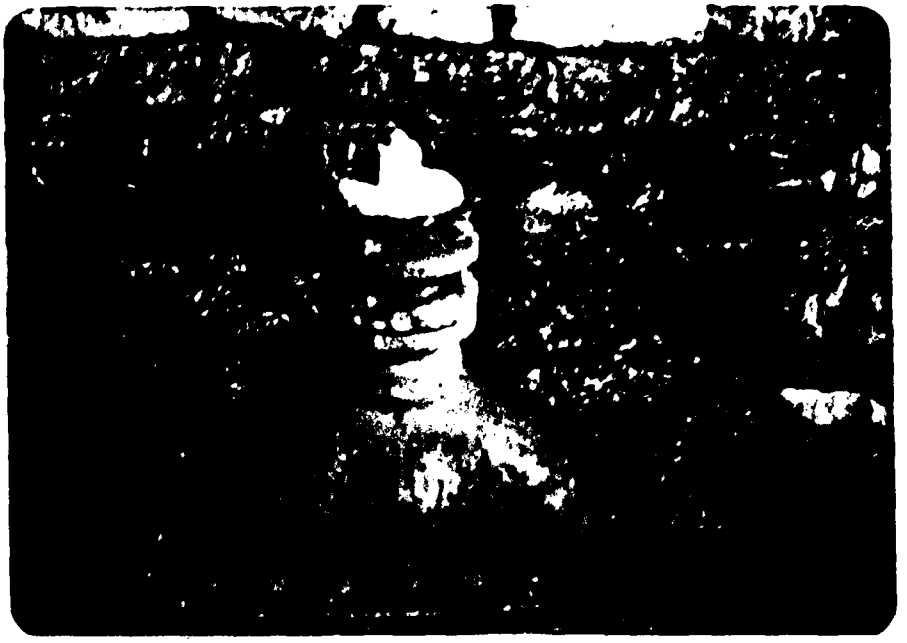
Spillway crest.

Photograph No. 3

Spillway discharge channel, looking upstream.

Photograph No. 4

Debris in spillway channel.



Photograph No. 5

Outlet valve in valve house.

Photograph No. 6

Route 30, 1/2 mile downstream (flow from left to right).

APPENDIX D

HYDROLOGY AND HYDRAULICS ANALYSES

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: Todd Spring Dam (NDI - I.D. PA 241)

PROBABLE MAXIMUM PRECIPITATION (PMP) = 23.9 INCHES/24 HOURS[1]

STATION	1	2	3	4	5
Station Description	Reservoir	Dam			
Drainage Area (square miles)	0.64	-			
Cumulative Drainage Area (square miles)	0.64	0.64			
Adjustment of PMP for Drainage Area (%)[2]					
6 Hours	102	-			
12 Hours	120				
24 Hours	130				
48 Hours	140				
72 Hours	-				
Snyder Hydrograph Parameters					
Zone[3]	21	-			
C_p/C_t[4]	0.55/1.50				
L (miles)[5]	1.8				
L_{ca} (miles)[5]	0.8				
$t_p = C_t(L \cdot L_{ca})^{0.3}$ (hours)	1.67				
Spillway Data					
Crest Length (ft)	-	See Attached Calculations			
Freeboard (ft)					
Discharge Coefficient					
Exponent					

(1) Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.

(2) Hydrometeorological Report 33 (Figure 2), U.S. Army, Corps of Engineers, 1956.

(3) Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

(4) Snyder's Coefficients.

(5) L = Length of longest water course from outlet to basin divide.
L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

STORAGE VS. ELEVATION

ELEVATION	ΔH, FEET	AREA (ACRES)[1]	ΔVOLUME (ACRE-FEET)[2]	STORAGE (ACRE-FEET)
1240	16	9.2	100	176
1224[3]	-	3.7	76[4]	76
Reservoir Bottom		-		0

(1) Planimetered from USGS maps.

(2) $\Delta Volume = \Delta H/3 \ (A_1 + A_2 + \sqrt{A_1 A_2})$.

(3) Normal pool elevation per owner's drawings.

(4) From PennDER files.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1                 A1       SNYDER UNIT HYDROGRAPH,FLOOD ROUTING AND DAM OVERTOPPING ANALYSES
    2                 A2       TODD SPRING DAM,BEDFORD COUNTY,NDI-I.D.PA.241     PROJECT NO.79-543-03
    3                 A3       FOR 20%,30%,40%,50%,60%,70%,80%,90%,AND 100% PMF
    4                 R    300        0       15        0        0        0        0        C       -4        C
    5                 R1     5
    6                 J      1        9        1
    7                 J1  0.20     0.30     0.40     0.50     0.60     0.70     0.80     0.90     1.00
    8                 K      0        1                                          1
    9                 K1       CALCULATION OF SNYDER INFLOW HYDROGRAPH TO TODD SPRING RESERVOIR
   10                 M      1        1     0.64                0.64                                1
   11                 P              23.9      102      120      130      140
   12                 T                                                    1.0      .05              0.0090
   13                 W   1.67     0.55
   14                 X   31.0    -0.05      2.0
   15                 K      1        2                                          1
   16                 K1       ROUTING FLOW THROUGH TODD SPRING DAM (NDI-I.D.PA.241)
   17                 Y                                        1        1
   18                 Y1     1                                                -1224.0       -1
   19                 Y41224.0   1224.5   1225.0   1225.5   1226.0   1226.5   1227.0   1227.5   1228.0   1229.0
   20                 Y5   0.0     39.1     110.5    219.6    360.5    530.5    719.4    942.1   1183.5   1713.7
   21                 S5   0.0     76.0    176.0
   22                 SE1184.0   1224.0   1240.0
   23                 SS1224.0
   24                 SD1225.5     3.08      1.5    625.0
   25                 SL   50.0    100.0    200.0    250.0    300.0    350.0    400.0    450.0    600.0    625.0
   26                 SW1225.5   1225.6   1225.7   1225.8   1225.9   1226.1   1226.5   1226.8   1226.9   1227.8
   27                 K     99
```

COMPUTER INPUT OVERTOPPING ANALYSIS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS								
				RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 .60	RATIO 6 .70	RATIO 7 .80	RATIO 8 .90	RATIO 9 1.00
HYDROGRAPH AT	1	.64	1	322.	483.	644.	805.	966.	1127.	1288.	1449.	1610.
	(	1.66)	(	9.12)(	13.68)(	18.24)(	22.79)(	27.35)(	31.91)(	36.47)(	41.03)(	45.59)
ROUTED TO	2	.64	1	320.	481.	641.	801.	962.	1122.	1282.	1442.	1606.
	(	1.66)	(	9.06)(	13.62)(	18.16)(	22.69)(	27.23)(	31.76)(	36.29)(	40.82)(	45.48)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1224.00	1224.00	1225.50
STORAGE	76.	76.	85.
OUTFLOW	0.	0.	220.

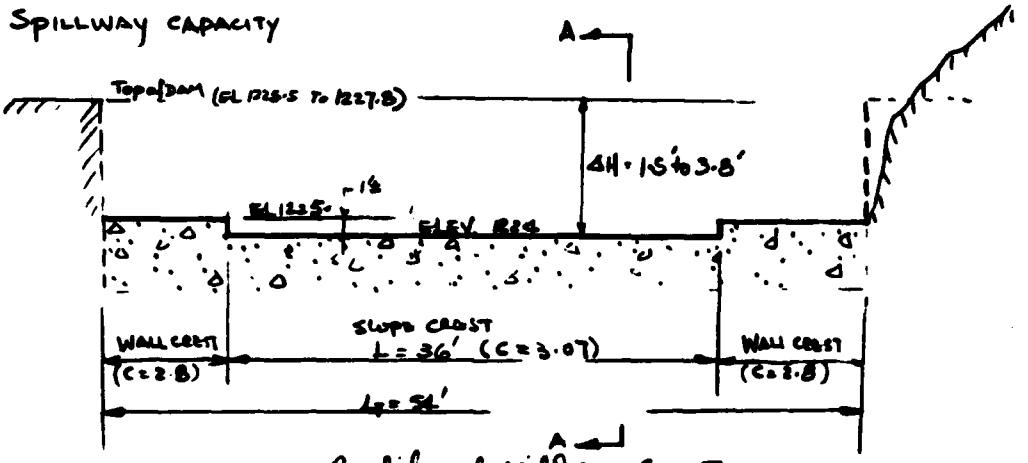
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	1225.73	.23	87.	320.	3.00	41.50	0.00
.30	1225.93	.43	88.	481.	4.75	41.50	0.00
.40	1226.07	.57	89.	641.	6.00	41.50	0.00
.50	1226.19	.69	90.	801.	7.25	41.50	0.00
.60	1226.29	.79	90.	962.	8.00	41.50	0.00
.70	1226.39	.89	91.	1122.	8.50	41.50	0.00
.80	1226.48	.98	91.	1282.	9.25	41.50	0.00
.90	1226.56	1.06	92.	1442.	9.75	41.25	0.00
1.00	1226.64	1.14	93.	1606.	10.25	41.25	0.00

OVERTOPPING ANALYSIS SUMMARY

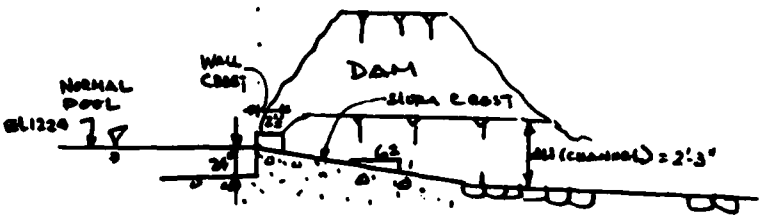
D'APPOLONIA
CONSULTING ENGINEERS, INC.

By WEC Date 12/22/79 Subject TODD SPRING DAM Sheet No. 1 of 2
Chkd. By MB Date 12/24/79 SPILLWAY RATING Proj. No. 79-543-03

Spillway Capacity



Profile of spillway crest



Section A-A

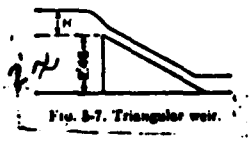


Fig. 5-7. Triangular weir.

REF TABLES 5-3, 5-6 & 5-7 ARE FROM HYDRAULIC HANDBOOK By King & Brater

Table 5-6. Values of C in the Formula $Q = CLH^{3/2}$ for Weirs of Triangular Cross Section with Vertical Upstream Face and Sloping Downstream Face

Slope of downstream face	Height of weir in feet, P	Head in feet, H										
		0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.3	1.6
Hor. Vert.												
1 to 1	2.40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 to 1	2.40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 to 1	1.04	0.000	0.07	0.07	0.07	0.000	0.07	0.07	0.000	0.000	0.000	0.07
5 to 1	1.04	....	0.000	0.11	0.000	0.000	0.000	0.07	0.000	0.000	0.01	0.01
8 to 1	2.40	....	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
10 to 1	2.40	....	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00

Table 5-7. Values of C in the Formula $Q = CLH^{3/2}$, Being the Mean and Extension of Experimental Results on Weirs of Triangular Cross Section with Vertical Upstream Face and Sloping Downstream Face

This table should be used only for heads above 0.7 ft.

Slope of downstream face	Value of C	Slope of downstream face	Value of C	Slope of downstream face	Value of C
Hor. Vert.		Hor. Vert.		Hor. Vert.	
1 to 1	2.48	0 to 1	2.47	12 to 1	2.80
2 to 1	2.56	7 to 1	2.68	16 to 1	2.80
3 to 1	2.55	8 to 1	2.68	18 to 1	2.78
4 to 1	2.51	9 to 1	2.84	16 to 1	2.72
6 to 1	2.50	10 to 1	2.80	20 to 1	2.80

D'APPOLONIA
CONSULTING ENGINEERS, INC.

By WTC Date 12/22/79 Subject TODD SPRING DAM Sheet No. 2 of 2
Chkd. By [illegible] Date 12/24/79 SPILLWAY RATING Proj. No. 79-543-03

$Q_1 = C_1 L_1 H_1^{1.5}$

$= (3.01)(36)(H_1^{1.5})$

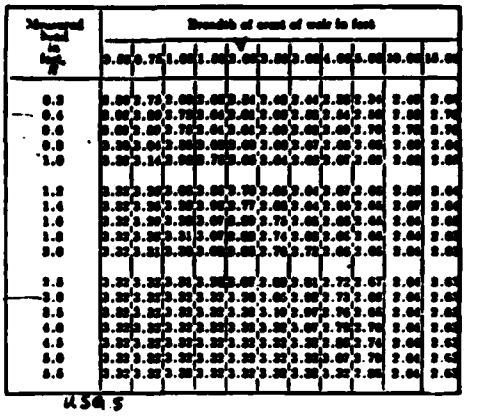
$= 110.52\, H^{1.5}$

$Q_2 = C_2 L_2 H_2^{1.5}$

$= C_2 (18)(H_2)^{1.5}$

$H_1 = H_2 + 1.0'$

Table 5-3. Values of C in the Formula $Q = CLH^{3/2}$ for Broad-crested Weirs



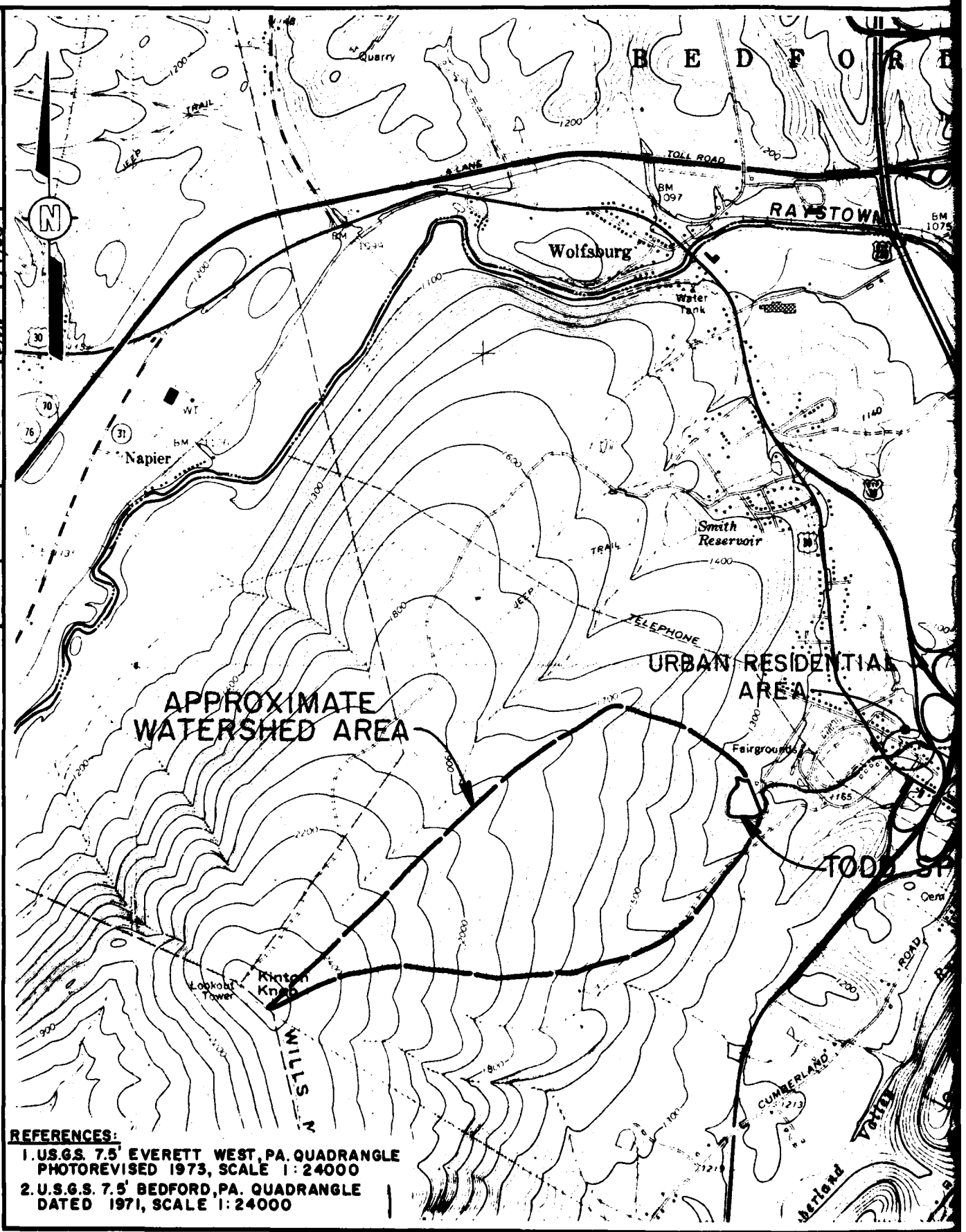
USGS

LAKE ELEV	H_1	C_1	Q_1	H_2	C_2	Q_2	Q_{TOTAL} cfs	Remark
1224.0	0	—	0	-	—	—	0	Spillway
1224.5	0.5	3.07	39.1	-	—	-	39.1	
1225.0	1.0		110.5	0	—	-	110.5	
1225.5	1.5		208.0	0.5	2.61	16.6	219.6	Dam crest - Low spot
1226.0	2.0		312.6	1.0	2.66	47.9	360.5	
1226.5	2.5		436.9	1.5	2.83	93.6	530.5	
1227.0	3.0		574.3	2.0	2.85	145.1	719.4	
1227.5	3.5		728.7	2.5	3.07	218.4	942.1	
1228.0	4.0		884.2	3.0	3.20	299.3	1183.5	- Dam crest high spot
1229.0	5.0		1235.7	4.0	3.32	478.1	1713.7	
1230.0	6.0	3.07	1624.3	5.0	3.32	668.1	2292.4	

APPENDIX E

PLATES

DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER 79-543-B12
	11-14-79	APPROVED BY	1/4/80	



REFERENCES:

1. U.S.G.S. 7.5' EVERETT WEST, PA. QUADRANGLE PHOTOREVISED 1973, SCALE 1:24000
2. U.S.G.S. 7.5' BEDFORD, PA. QUADRANGLE DATED 1971, SCALE 1:24000

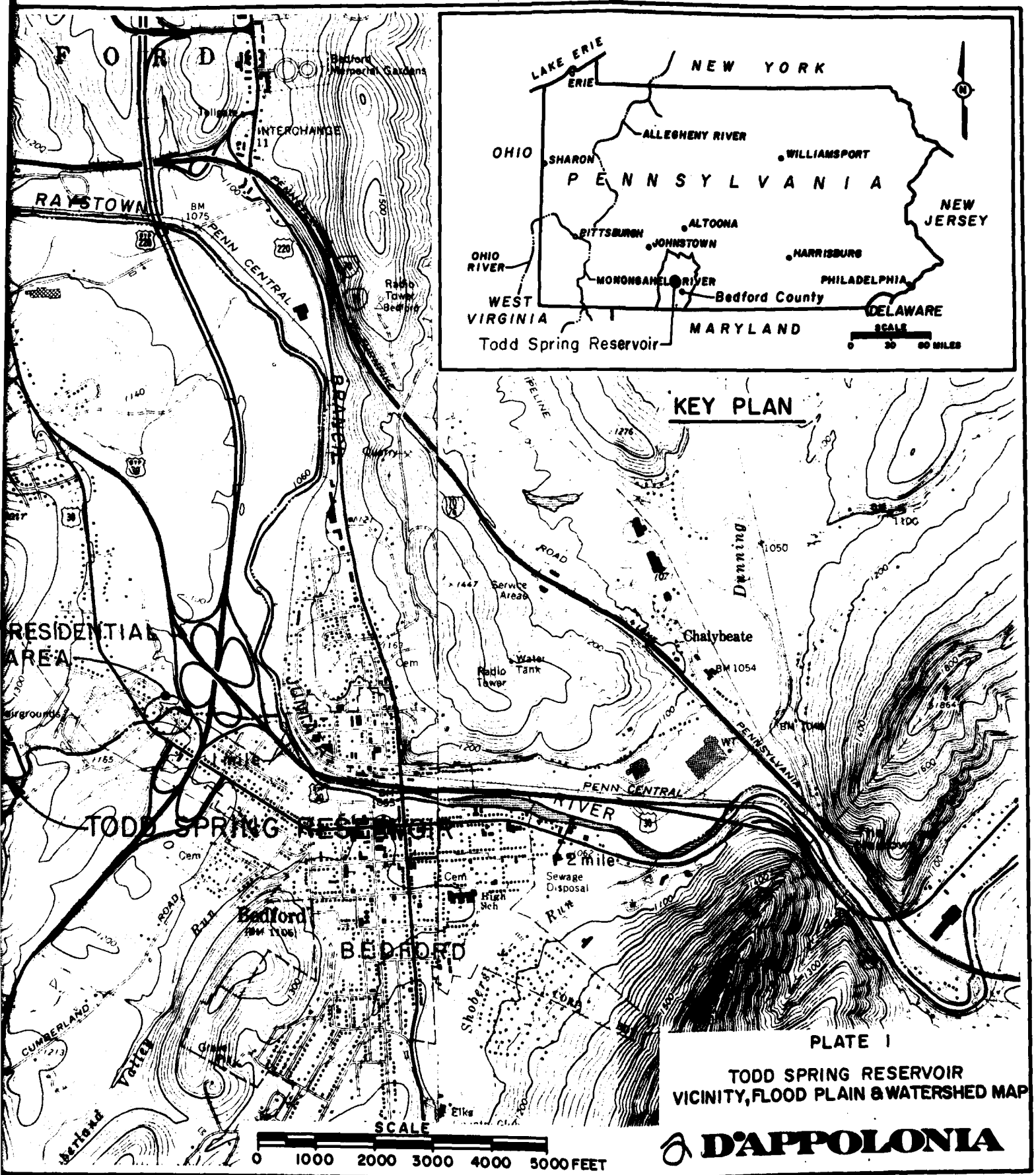
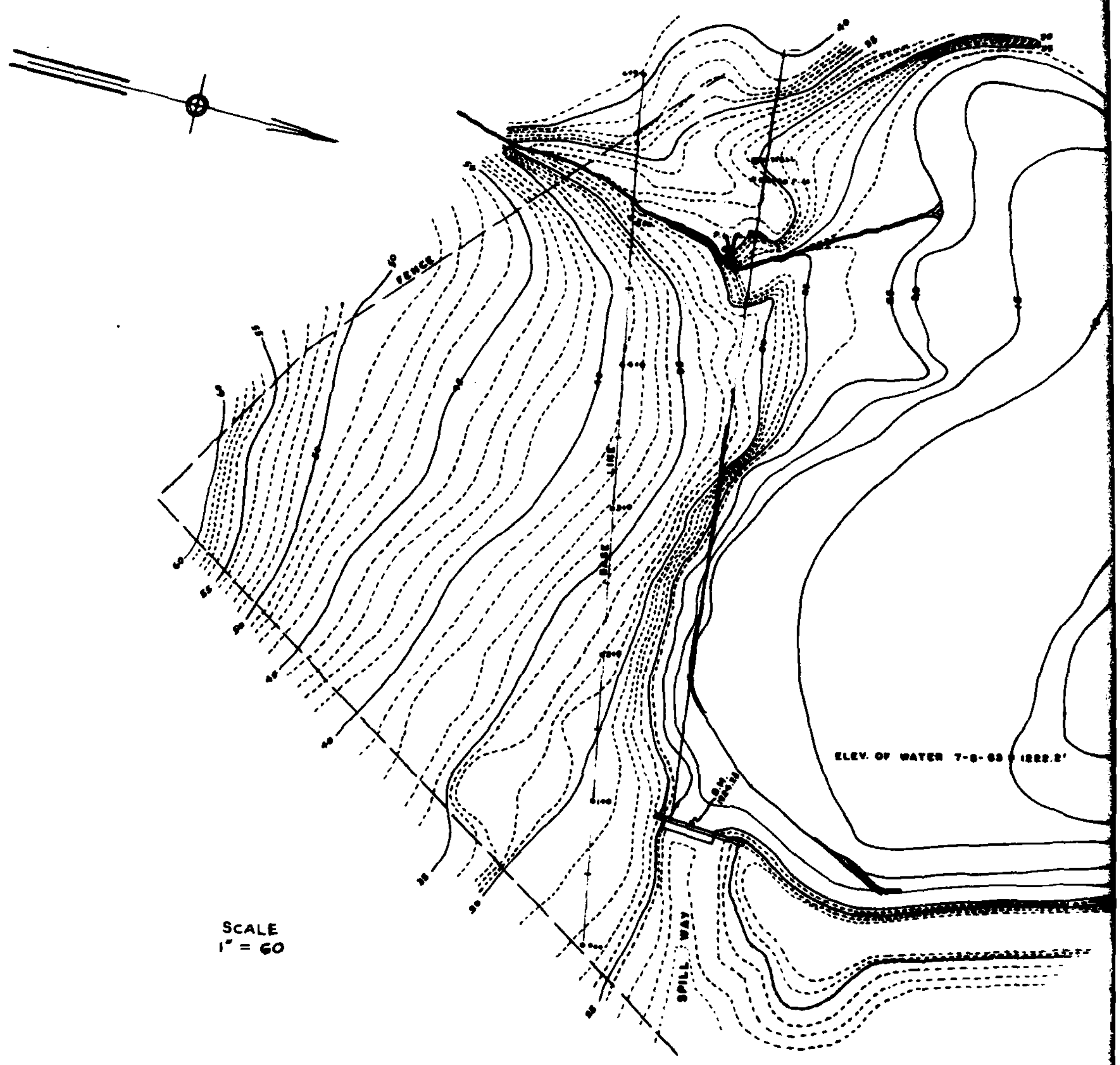


PLATE 1

TODD SPRING RESERVOIR
VICINITY, FLOOD PLAIN & WATERSHED MAP

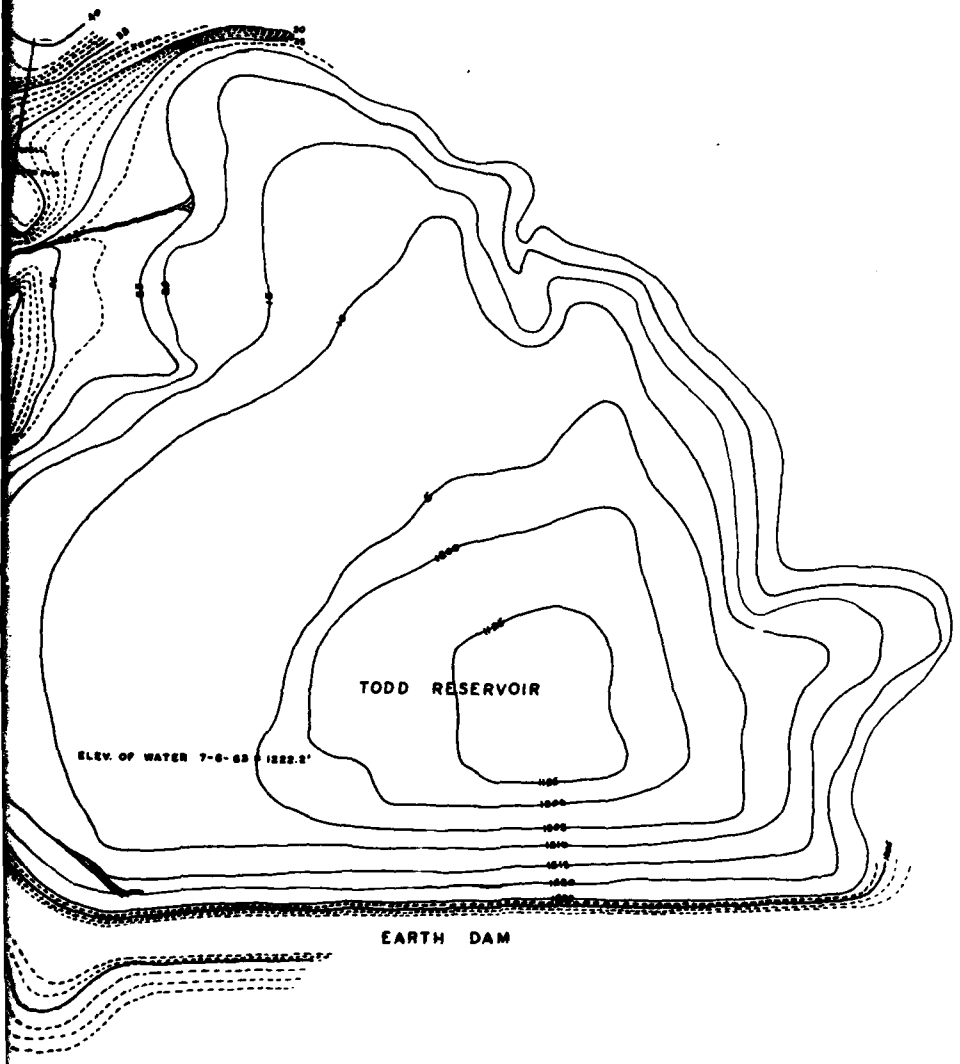
D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	[illegible]	1/4/80	DRAWING NUMBER
	12-31-79	APPROVED BY	[illegible]	1/4/80	79-543-B13



CONTO

PE11138



CONTOUR PLAN OF THE SOUTH BANK OF THE TODD RESERVOIR

BEDFORD BORO. WATER SYSTEM

PE11138

CONTOUR INTERVAL = 1 FOOT ON BANK & 5 FEET IN BASIN

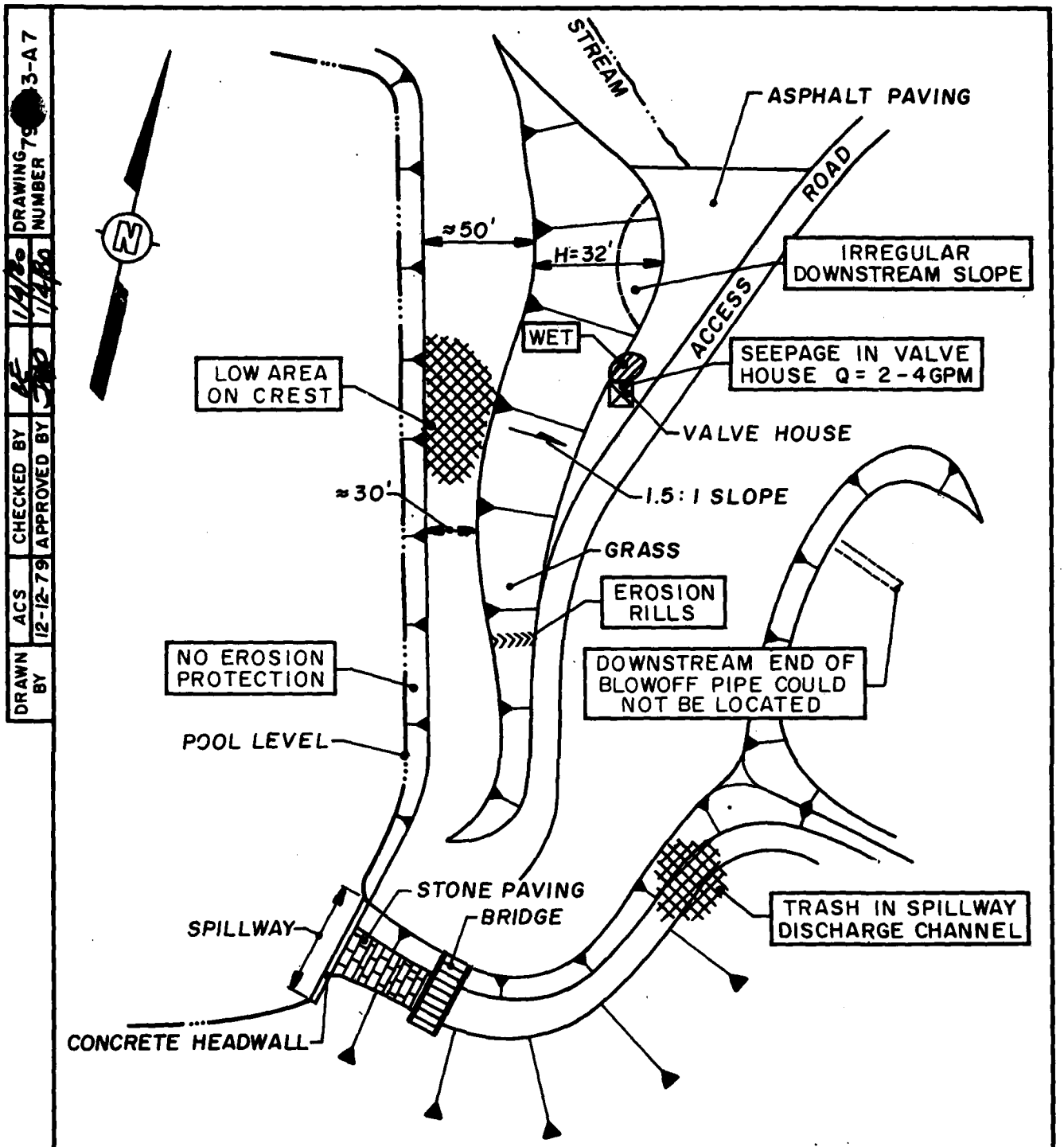
BANK SURVEYED JULY 6, 8 & 9, 1963 BASIN SURVEYED FEB. 5, 1954

R. S. BEAM R.P.E. CALTON HECKERMAN BORO. ENGR.

2

PLATE 2

D'APPOLONIA



DRAWN BY	CHECKED BY	DRAWING NUMBER
ACS		3-A7
12-12-79	APPROVED BY	

NOTE:

1. POOL LEVEL DATE OF INSPECTION: 1/2-INCH ABOVE SPILLWAY CREST

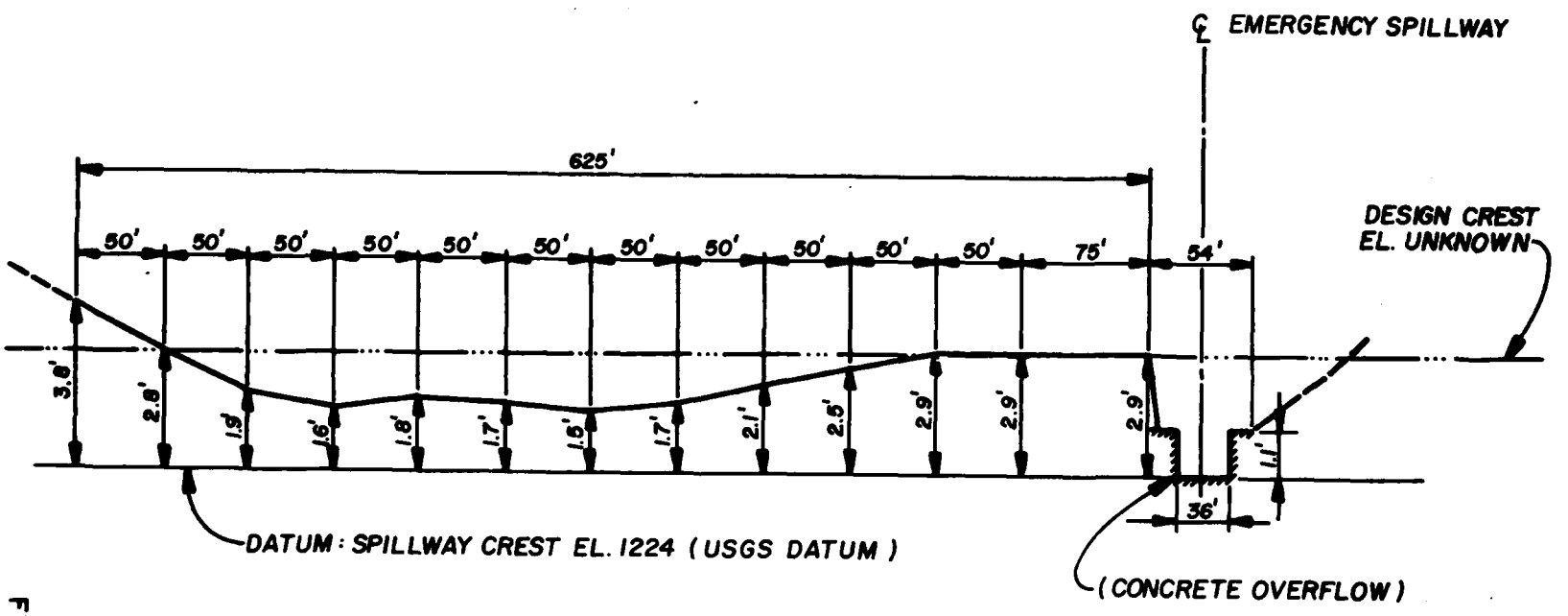
NOT TO SCALE

PLATE 3

TODD SPRING RESERVOIR
GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE: NOV. 19, 1979

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	RE	1/9/80	DRAWING NUMBER 79-43-A 8
	12-10-79	APPROVED BY	[illegible]	1/14/80	



DAM CREST PROFILE
(LOOKING DOWNSTREAM)

NOTES:

1. DAM CREST IS SURVEYED RELATIVE TO SPILLWAY CREST LEVEL.
2. DATUM ELEVATION PER OWNER'S DRAWINGS.

PLATE 4

TODD SPRING RESERVOIR
DAM CREST SURVEY
FIELD INSPECTION DATE: NOV. 19, 1979

D'APPOLONIA

APPENDIX F
REGIONAL GEOLOGY

APPENDIX F

REGIONAL GEOLOGY
TODD SPRING DAM

Todd Spring Dam is located on rock strata of Silurian Age. The dam and reservoir lie near the boundary of the Rose Hill Formation (CLinton Group) and the overlying Tuscarora Formation. The Rose Hill Formation is a greenish-gray thin to medium bedded shale with interbedded siltstone and sandstone layrs. Gray, hard, massive, quartzitic sandstone layers comprise the Tuscarora Formation, which is resistant to weathering.

The dam is located on the east flank of the Wills Mountain anticline, a feature that trends and plunges to the northeast. Rock strata dip approximately 15 degrees to the southeast. The slopes around the reservoir are 15 to 20 degrees and could be susceptible to sliding along bedding planes of the shale.

DRAWN BY ACS 12-31-79
CHECKED BY
APPROVED BY
DRAWING NUMBER 79 B-A11

N

SCALE
0 2 4 6 8 10miles

REFERENCE:
GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA., DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

JOSEPH SMYTH DAM, MILBURN SPRING AND TODD SPRING RESERVOIR

GEOLOGY MAP

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER 79-043-A18
	12-31-79	APPROVED BY		

LEGEND:

Pc — **Conemaugh Formation**
Cyclic sequences of red and gray shales and siltstones with thin limestones and coals; massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of section; Brush Creek Limestone in lower part of section.

Pottsville Group
Light gray to white, coarse grained sandstones and conglomerates with some minerable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

Allegheny Group
Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward; Vanport Limestone in lower part of section; includes Freeport, Kittanning, and Clarion Formations.

Clinton Group
Predominantly Rose Hill Formation - Reddish purple to greenish gray, thin to medium bedded, fossiliferous shale with intertonguing "iron sandstones" and local gray, fossiliferous limestone; above the Rose Hill is brown to white quartzitic sandstone (Keefer) interbedded upward with dark gray shale (Rochester).

Dm — **Marine beds**
Gray to olive brown shales, graywacke, and sandstones; contains "Chemung" beds and "Portage" beds including Burket, Brallier, Harrell, and Trimmers Rock; Tully Limestone at base.

Pocono Group
Predominantly gray, hard, massive, cross-bedded conglomeratic and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cussewago, Corry, and Knapp Formations; includes part of "Oswayo" of M. L. Fuller in Potter and Tioga counties.

Oriskany Formation
White to brown, fine to coarse grained, partly calcareous, locally conglomeratic, fossiliferous sandstone (Ridgeley) at the top; dark gray, cherty limestone with some interbedded shales and sandstones below (Shriver).

Tuscarora Formation
White to gray, medium to thick bedded, fine grained, quartzitic sandstone, conglomeratic in part.

Marcellus Formation
Black, fissile, carbonaceous shale with thick, brown sandstone (Turkey Ridge) in parts of central Pennsylvania.

Onondaga Formation
Greenish blue, thin bedded shale and dark blue to black, medium bedded limestone with shale predominant in most places; includes Selinsgrove Limestone and Needmore Shale in central Pennsylvania and Buttermilk Falls Limestone and Esopus Shale in easternmost Pennsylvania; in Lehigh Gap area includes Palmerton Sandstone and Bowmanstown Chert.

Dmo

Wills Creek Formation
Greenish gray, thin bedded, fissile shale with local limestone and sandstone zones; contains red shale and siltstone in the lower part.

Bloomsburg Formation
Red, thin and thick bedded shale and siltstone with local units of sandstone and thin impure limestone; some green shale in places.

McKenzie Formation
Greenish gray, thin bedded shale interbedded with gray, thin bedded, fossiliferous limestone; shale predominant at the base; intraformational breccia in the lower part. Absent in Harrisburg quadrangle and to the east.

Keyser Formation
Dark gray, highly fossiliferous, thick bedded, crystalline to nodular limestone; passes into Manlius, Rondout, and Decker Formations in the east.

Tonoloway Formation
Gray, highly laminated, thin bedded, argillaceous limestone; passes into Bossardville and Pozono Island beds in the east.

Catskill Formation
Chiefly red to brownish shales and sandstones; includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River in the east.

REFERENCE:
GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA. DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

GEOLOGY MAP LEGEND

D'APPOLONIA